

WHAT IS CLAIMED IS:

1. A semiconductor device stacked a gate insulating film and a gate electrode in this order on a silicon substrate; wherein
said gate insulating film comprises a nitrogen containing high-dielectric-constant insulating film which has a structure in which nitrogen is
5 introduced into metal oxide or metal silicate; and
the nitrogen concentration in said nitrogen containing high-dielectric-constant insulating film has a distribution in the direction of the film thickness; and
a position at which the nitrogen concentration in said nitrogen
10 containing high-dielectric-constant insulating film reaches a maximum in the direction of the film thickness is present in a region at a distance from the silicon substrate.
2. A semiconductor device according to Claim 1, wherein a position at which the nitrogen concentration in said nitrogen containing high-dielectric-constant insulating film reaches a maximum in the direction of the film thickness is present in a region at a distance of not less than 0.5 nm
5 from the silicon substrate.
3. A semiconductor device according to Claim 1, wherein a position at which the nitrogen concentration in said nitrogen containing high-dielectric-constant insulating film reaches a maximum in the direction of the film thickness is localized on the side of a gate electrode in said nitrogen
5 containing high-dielectric-constant insulating film.

4. A semiconductor device according to Claim 1, wherein a position at which the nitrogen concentration in said nitrogen containing high-dielectric-constant insulating film reaches a maximum in the direction of the film thickness is localized in the central section of said nitrogen containing high-dielectric-constant insulating film.

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5. A semiconductor device according to one of Claims 1-4, wherein the nitrogen concentration on a silicon substrate side interface of said gate insulating film is less than 3 atomic %.

6. A semiconductor device stacked a gate insulating film and a gate electrode in this order on a silicon substrate; wherein said gate insulating film comprises a nitrogen containing high-dielectric-constant insulating film which has a structure in which nitrogen is introduced into metal silicate; and

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a nitrogen atom in said nitrogen containing high-dielectric-constant insulating film selectively bonds with a silicon atom in metal silicate.

7. A semiconductor device according to Claim 6, wherein a nitrogen atom which selectively bonds with a silicon atom in said metal silicate is situated at a distance from the silicon substrate.

8. A semiconductor device according to one of Claims 1-7, wherein said gate insulating film comprises a silicon oxide film formed on said silicon substrate so as to be in contact therewith, and said nitrogen containing high-dielectric-constant insulating film formed on said silicon oxide film so as to

5 be in contact therewith.

9. A semiconductor device stacked a gate insulating film and a gate electrode in this order on a silicon substrate; wherein

said gate insulating film comprises a nitrogen containing high-dielectric-constant insulating film which has a structure in which nitrogen is
5 introduced into metal silicate; and

the composition of said nitrogen containing high-dielectric-constant insulating film continuously varies in the direction of the film thickness and the silicon concentration has a minimum value in the middle section lying between a silicon substrate side interface of said nitrogen containing
10 high-dielectric-constant insulating film and a gate electrode side interface thereof; and

nitrogen is introduced only into a region lying between the position at which the silicon concentration has the minimum value and said gate electrode side interface.

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10. A semiconductor device stacked a gate insulating film and a gate electrode in this order on a silicon substrate; wherein

said gate insulating film has a layered structure having, from the silicon substrate side, a first silicon oxide film, a metal oxide film or a metal silicate film
5 and a second silicon oxide film; and

only the second silicon oxide film has a structure in which nitrogen is introduced into silicon oxide.

11. A semiconductor device according to one of Claims 1-10. wherein

said silicon substrate and said gate insulating film are in contact with each other, and said gate insulating film and a gate electrode are in contact with each other; and

5 said gate electrode is made of either a polysilicon or a polysilicon germanium conductive film.

12. A semiconductor device according to one of Claims 1-11, wherein said gate insulating film contains at least one type selected from the group consisting of Zr, Hf, Ta, Al, Ti, Nb, Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu.

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13. A method of manufacturing a semiconductor device having, on a silicon substrate, a gate insulating film and a gate electrode in this order, wherein

5 said semiconductor device is a semiconductor device according to one of Claims 1-9: which comprises the step of

 making said introduction of nitrogen by irradiating said high-dielectric constant insulating film which is made of metal oxide or metal silicate, with a nitrogen containing plasma.

14. A method of manufacturing a semiconductor device having, on a silicon substrate, a gate insulating film and a gate electrode in this order, wherein

5 said semiconductor device is a semiconductor device according to Claim 10: which comprises the step of

 making said introduction of nitrogen by irradiating layered structure

with a nitrogen containing plasma.

15. A method of manufacturing a semiconductor device having, on a silicon substrate, a gate insulating film and a gate electrode in this order, wherein

said semiconductor device is a semiconductor device according to
5 Claim 6 or 7; which comprises the step of
irradiating said high-dielectric constant insulating film which is made of metal silicate, with a nitrogen containing plasma, so as to form, selectively, bonds between silicon and nitrogen in metal silicate, and thereby making said introduction of nitrogen.

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16. A method of manufacturing a semiconductor device having, on a silicon substrate, a gate insulating film and a gate electrode in this order, wherein

said semiconductor device is a semiconductor device according to one
5 of Claims 1-9: which comprises the step of
forming, on the silicon substrate, a layered structure made of a metal layer and a nitrogen containing layer that contains nitrogen, and thereafter applying an oxidation treatment to form a gate insulating film.

17. A method of manufacturing a semiconductor device according to Claim 16, wherein said nitrogen containing layer is one of a silicon oxynitride film and a silicon nitride film.

18. A method of manufacturing a semiconductor device according to

Claim 16, wherein said nitrogen containing layer is a metal nitride film.

19. A method of manufacturing a semiconductor device according to one of Claims 16-18, wherein said layered structure is formed after a silicon oxide film with a film thickness of less than 1 nm is formed on the surface of the silicon substrate.

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20. A semiconductor device having, on a silicon substrate, a gate insulating film and a gate electrode in this order; wherein

said gate insulating film contains nitrogen and metal oxide or metal silicate; and

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the nitrogen concentration in said gate insulating film has a distribution in the direction of the film thickness; and

a position at which the nitrogen concentration in said gate insulating film reaches a maximum in the direction of the film thickness is present in a region at a distance from the silicon substrate.